PATENT SPECIFICATION

DRAWINGS ATTACHED

856,473

Date of Application and filing Complete Specification: April 1, 1959.

No. 11065/59.

Complete Specification Published: Dec. 14, 1960.

SPECIFICATION NO. 856,473

INVENTOR: JOHN OLIVER CREEK

By a direction given under Section 17 (1) of the Patents Act 1949 this application proceeded in the name of Minister of National Defence for Canada, of the city of Ottawa, County of Carleton, Province of Ontario, Canada.

THE PATENT OFFICE,
17th February, 1961

DS 87202/1(48)/R.153 200 2/61

the Village of Malton, County of Peel, Province of Ontario, Canada, a Canadian citizen, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of and apparatus for stretch forming sheet metal sections for the manufacture of gas turbine blades.

The manufacture of sheet metal gas turbine blades is undergoing considerable development in the aircraft industry due to the advantages that these blades have over solid blades in present day gas turbine engines. In forming the skin for a sheet metal gas turbine blade, it is quite common to stretch the sheet metal during the forming operation and conventional practices involve the use of an oversized sheet which is gripped and stretched by means external of the die form. This results in the use of a considerably more sheet metal than is required to form the desired section and, as a result, increases the cost of the manufacturing process.

The present invention provides a method whereby a large portion of this excess sheet metal may be saved and also provides a press and forming mechanism which is simple, cheap and efficient.

The present invention consists in the method of forming sheet metal sections for gas turbine blades comprising the steps of forming a rectangular sheet of sheet metal, turning up and over at least one pair of opposed edges to form a flanged blank, loading the flanged blank with a mass of deformable filler material encompassed by the sheet and the flanges, placing the loaded flanged blank in a press between a concave and a convex die, applying pressure to the dies to force the sheet to conform to the shape of the adjacent die, restraining the mutually presented edges of the flanges from separation in a direction transverse to the direction of die pressure and ... stretching of the sheet due to the lateral pressure exerted by the deformable filler material under the influence of the die pressure.

One form of the apparatus which may be used to perform the blade forming method is illustrated, by way of example, in the accompanying drawings in which:

Figure 1 is an exploded perspective view of a press tool with a flanged and loaded blank in position;

Figure 2 is a perspective view of the rough blank of sheet metal before bending;

Figure 3 is a perspective view of the blank with the flanges partially formed;

Figure 4 is a perspective view of the fully flanged and loaded blank;

Figure 5 is a transverse section through the press tool containing a flanged and loaded blank during the pressing operation of a convex section;

Figure 6 is a view similar to Figure 5 during the forming of a concave section; and

Figure 7 is a front elevation view of a typical press with which the present invention may be used.

Referring now to Figure 1, the press tool may be seen to comprise a base 10 which is mounted upon a press bolster plate 38 and which carries, upon its upper surface, a lower die 11 having a convex upper working surface 12. At either end of the die 11 is an end block 13 and 14, end block 14 being movable in the direction of arrow 15 by means of a key 16 fitting in a key-way 17 cut in the upper surface of the base 10.

The upper element of the press tool comprises a supporting block 18 upon the lower surface of which is mounted the upper die 19 which has a concave lower working surface 20. At one end of the working surface 20 of the upper die 19 is a block 21 and, at the other, a block 22 each of which is provided with a slide 23 and 24 which are adapted to move in slots 25 and 26 respectively in end blocks 13 and 14. It will thus be seen that when the up-

PATENT SPECIFICATION

DRAWINGS ATTACHED

856,473

Date of Application and filing Complete Specification: April 1, 1959.

No. 11065/59.

Complete Specification Published: Dec. 14, 1960.

Index at acceptance:—Classes 83(2), A166; and 83(4), E(1D3: 8E: 10A9).

International Classification:—B23k, p.

COMPLETE SPECIFICATION

Method and apparatus for Forming Sheet Metal Blade Sections

I, JOHN OLIVER CREEK, whose post office address is care of Orenda Engines Limited, of the Village of Malton, County of Peel, Province of Ontario, Canada, a Canadian citizen, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of and apparatus for stretch forming sheet metal sections for the manufacture of gas turbine blades.

The manufacture of sheet metal gas turbine blades is undergoing considerable development in the aircraft industry due to the advantages that these blades have over solid blades in present day gas turbine engines. In forming the skin for a sheet metal gas turbine blade, it is quite common to stretch the sheet metal during the forming operation and conventional practices involve the use of an oversized sheet which is gripped and stretched by means external of the die form. This results in the use of a considerably more sheet metal than is required to form the desired section and, as a result, increases the cost of the manufacturing process.

The present invention provides a method whereby a large portion of this excess sheet metal may be saved and also provides a press and forming mechanism which is simple, cheap and efficient.

The present invention consists in the method of forming sheet metal sections for gas turbine blades comprising the steps of forming a rectangular sheet of sheet metal, turning up and over at least one pair of opposed edges to form a flanged blank, loading the flanged blank with a mass of deformable filler material encompassed by the sheet and the flanges, placing the loaded flanged blank in a press between a concave and a convex die, applying pressure to the dies to force the sheet to conform to the shape of the adjacent die, restraining the mutually presented edges of the flanges from separation in a direction transverse to the direction of die pressure and continuing the application of pressure to cause a lateral stretching of the sheet due to the lateral pressure exerted by the deformable filler material under the influence of the die pressure.

One form of the apparatus which may be used to perform the blade forming method is illustrated, by way of example, in the accompanying drawings in which:

Figure 1 is an exploded perspective view of a press tool with a flanged and loaded blank in position;

Figure 2 is a perspective view of the rough blank of sheet metal before bending;

Figure 3 is a perspective view of the blank with the flanges partially formed;

Figure 4 is a perspective view of the fully flanged and loaded blank;

Figure 5 is a transverse section through the press tool containing a flanged and loaded blank during the pressing operation of a convex section;

Figure 6 is a view similar to Figure 5 during the forming of a concave section; and

Figure 7 is a front elevation view of a typical press with which the present invention may be used.

Referring now to Figure 1, the press tool may be seen to comprise a base 10 which is mounted upon a press bolster plate 38 and which carries, upon its upper surface, a lower die 11 having a convex upper working surface 12. At either end of the die 11 is an end block 13 and 14, end block 14 being movable in the direction of arrow 15 by means of a key 16 fitting in a key-way 17 cut in the upper surface of the base 10..

The upper element of the press tool comprises a supporting block 18 upon the lower surface of which is mounted the upper die 19 which has a concave lower working surface 20. At one end of the working surface 20 of the upper die 19 is a block 21 and, at the other, a block 22 each of which is provided with a slide 23 and 24 which are adapted to move in slots 25 and 26 respectively in end blocks 13 and 14. It will thus be seen that when the up-

[*Price 3s. 6d.*]

per element of the press tool is moved downwardly into engagement with the lower element, slides 23 and 24 will enter slots 25 and 26 and, as a result, the upper element of the die will be guided in its downward movement so that the working face 20 of the upper die 19 will be directly superimposed over the working face 12 of the lower die 11. The lower convex working face 12, in co-operation with the upper concave working face 20 will, when the two elements are brought together under pressure, by means such as the hydraulic press 37 seen in Figure 7, form a workpiece which is placed between them to the desired configuration represented by the configuration of the respective working faces of the lower and upper dies.

Referring now to Figures 2 to 4 inclusive the steps in forming the flanged and loaded blank may be seen. In Figure 2 a piece of sheet metal is shown of substantially rectangular configuration, the pair of opposed shorter sides having extending therefrom and substantially centrally disposed, a pair of tabs 27 and 28 for a purpose which will later be described. The first step of the forming operation is to turn up one pair of opposed edges 29 and 30 of the sheet 31 to form the configuration shown in Figure 3. At this point the blank may be loaded with a mass of plastic, deformable material 32 whereupon the edges 29 and 30 of the sheet 31 are folded over to encompass the loading material 32 as shown in Figure 4.

The plastic, deformable filler material 32 may be a material such as lead, a material sold under the Registered Trade Mark " CERROBEND ", or any other appropriate plastic flow medium, many types of which are well known in the trade.

Having produced the flanged and loaded blank shown in Figure 4, it is then inserted in the press tool in the manner shown in Figure 1 with the tabs 27 and 28 fitting in notches 33 and 34 in end blocks 13 and 14 at either end of the working surface 12 of the lower die 11. The tabs 27 and 28 fitting in notches 33 and 34 serve to position the flanged and loaded blank on the convex working surface 12 of the lower die 11.

A consideration of Figures 1, 5 and 6 will serve to show that the working surface which lies opposite to the surface of the sheet 31 is provided with workpiece gripping serrations 35 which extend the full length of the die 11 and which are parallel to each other and parallel to the longitudinal centre line of the working face 12 of the lower die 11. As may be seen in Figure 5, the serrations are substantially saw-tooth in form and are inclined inwardly towards the longitudinal centre line of the working face 12 of the lower die 11, the serrations being of greater depth adjacent the centre line of the die than at the edge, the serrations decreasing in depth progressively as they approach the edge of the working face of the die. In Figure 5 it may be seen that as the upper die 19 is forced towards the lower die 11, the mutually presented edges 29 and 30 of the flanges on the flanged and loaded blank between the two dies will be urged into intimate contact with the gripping serrations 35 which will bite into the surface of the sheet metal and restrain them against separation or a lateral displacement in a direction transverse to the direction of application of pressure by the upper die 19. The serrations decrease in depth as they approach the edge of the die so that there will be no tendency for the serrations to bite completely through the sheet metal and sever it at any point. This tends to ensure that the load is evenly distributed over all the serrations, the load being a function of the elongation of the sheet metal under tension.

As the upper die 19 is formed closer and closer to the lower die 11, the loading material 32 will become distorted and the sheet 31 will be forced to conform to the working surface of the die adjacent to it. In Figure 5 this adjacent working face will be concave surface 20 of the upper die 19. Further increase of pressure exerted by the upper die 19 will cause the thickness of the loading material 32 to be reduced but since its volume remains constant, there will be an expansion of the loading material in a direction transverse to the direction of application of pressure by the upper die 19. This will result in the filler material tending to squeeze out between the upper and lower die along the edges of these dies in the direction of the arrows 36 in Figures 5 and 6. As a result, the sheet 31 will be stretched during the pressing operation which will result in the sheet being formed to the desirable configuration and will eliminate the tendency of the sheet 31 to spring back to its original flat condition when the pressure is removed from the upper die 19.

The end blocks 13 and 14 are provided for the purpose of preventing the loading material 32 from being squeezed out of the flanged and loaded blank at the ends thereof which, in the blank form, are not closed. Since the application of pressure by the upper die 19 will force the loading material 32 into intimate contact with end blocks 13 and 14, the end block 14 is mounted so as to be slidable away from the lower die 11 to facilitate the removal of the pressed blank when the upper die 19 is lifted from its lowermost position. In order to prevent the movement of the end block 14, however, during the pressing operation the end blocks 21 and 22 of the upper element of the die are provided with surfaces 39 which, when the upper element has engaged the lower element, bear against surfaces 40 and 41 of end blocks 13 and 14 respectively to restrain end block 14 from movement in the direction of the arrow 15.

From a comparison of Figures 5 and 6 it will be seen that the workpiece gripping serrations 35 are, in each case, placed on the working face of that die which will lie opposite to the sheet 31 which it is desired to form. Accordingly, when it is desired to form a concave section which will be formed by pressing the workpiece against a convex die, the workpiece gripping serrations will be provided along the edges of the working face of the concave die as seen in Figure 6. Similarly, when it is desired to form a convex section which will be formed by pressing the sheet against the surface of a concave die, the workpiece gripping serrations will be mounted along the edge of the working surface of the convex die as seen in Figure 5.

It has been found, in practice, that more convenient operation may be achieved by maintaining the working surface 12 of the lower die always of convex configuration. Accordingly, it will be seen in Figure 5 and Figure 6 that the lower die 11 has, in both cases, a convex working surface 12 which is presented to the concave working surface 20 of the upper die 19. The location of the workpiece gripping serrations 35 however, varies depending on whether it is desired to produce a concave section from the sheet 31 or a convex section.

Although not shown in Figure 1, the die elements disclosed therein are suitable for use in a conventional hydraulic, pneumatic or mechanical device which is designed to apply pressure between two opposed faces. Since the precise structure of the pressure applying means forms no part of the present invention it has been illustrated only schematically in Figure 7 in the form of a hydraulic press 37 having a bed 139, a pair of vertical slides 140 and a hydraulic cylinder 141. The press tool of Figure 1 may be seen located between the opposed faces of the bed 139 and the pressure plate 42.

While the invention has been described specifically with reference to one embodiment illustrated in the accompanying drawings it is intended that minor modifications may be made within the scope of the appended claims.

WHAT I CLAIM IS: —

1. The method of forming sheet metal sections for gas turbine blades comprising the steps of forming a rectangular sheet of sheet metal, turning up and over at least one pair of opposed edges to form a flanged blank, loading the flanged blank with a mass of deformable filler material encompassed by the sheet and the flanges, placing the loaded flanged blank in a press between a concave and a convex die, applying pressure to the dies to force the sheet to conform to the shape of the adjacent die, restraining the mutually presented edges of the flanges from separation in a direction transverse to the direction of die pressure and continuing the application of pressure to cause a lateral stretching of the sheet due to the lateral pressure exerted by the deformable filler material under the influence of the die pressure.

2. Apparatus for stretch forming sheet metal sections of gas turbine blades comprising a fixed lower convex die and a movable upper concave die, each die having a working face adapted to contact the workpiece inserted between them, the working face of one of the dies having a series of workpiece gripping serrations along each side of its working face to engage the workpiece and prevent displacement of the workpiece in a direction transverse to the direction of application of pressure, guide means to restrain the movable die against lateral displacement, the lower convex die having a working face terminated at either end by a flat vertical end wall, one of the end walls being movable from a first position adjacent the end of the working face to a second position spaced therefrom, means to force the movable die into engagement with the fixed die under pressure and means to retain the movable end wall associated with the lower die in its first position during the application of pressure to the upper die.

3. Apparatus as claimed in claim 2 in which the workpiece gripping serrations constitute ridges having sharp edges inclined towards the centre of the working face of the die.

4. Apparatus as claimed in claim 2 in which the serrations are parallel to each other and parallel to the longitudinal centre line of the working face of the die and extend the full length of the die.

5. Apparatus as claimed in claim 2 in which the end walls on the lower convex die have vertically extending grooves on their adjacent faces to receive located lugs on a workpiece.

BARON & WARREN,
16, Kensington Square, London, W.8.
Chartered Patent Agents.

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press.—1960.
Published by The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

856,473 COMPLETE SPECIFICATION
I SHEET
This drawing is a reproduction of the Original on a reduced scale.

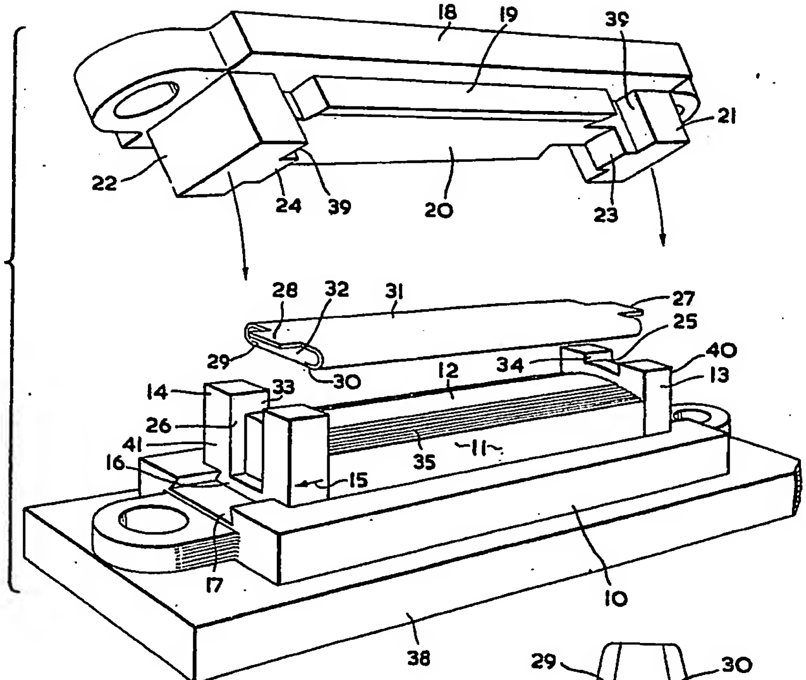

FIG. 1

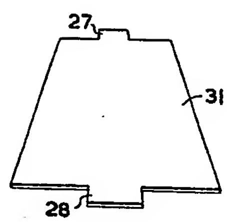

FIG. 2

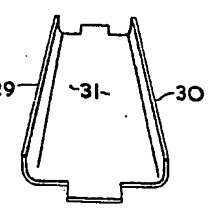

FIG. 3

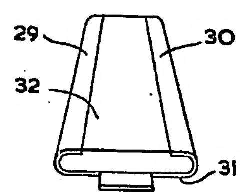

FIG. 4

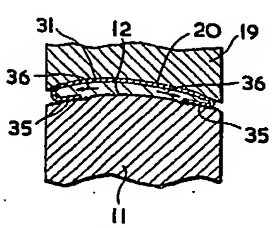

FIG. 5

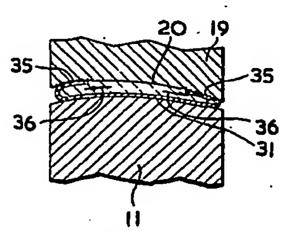

FIG. 6

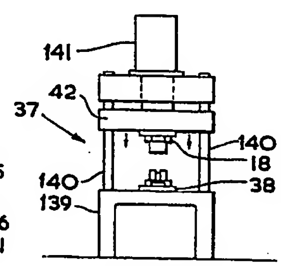

FIG. 7